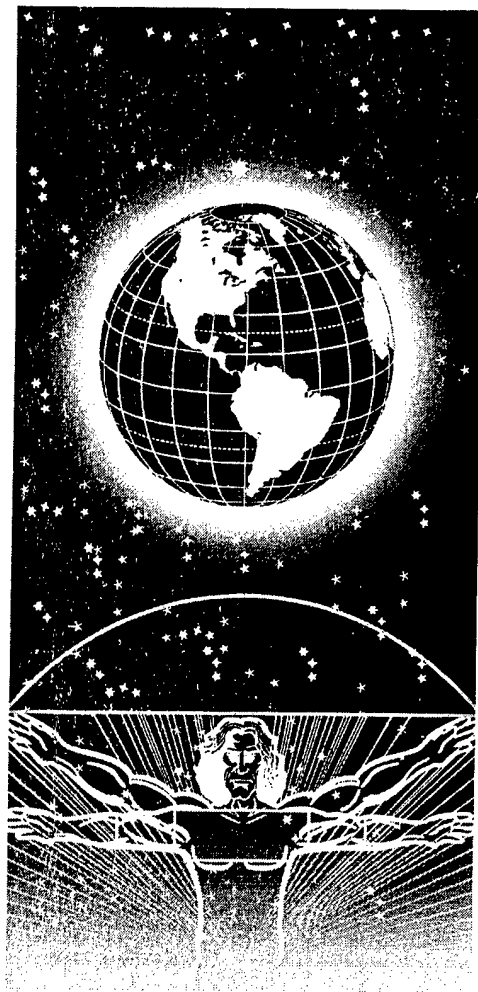


**UNITED STATES AIR FORCE
RESEARCH LABORATORY**

**TESTING AND EVALUATION OF THE
CEOTRONICS, INC., MODEL TC 917
WIRELESS HEADSET**

Allen E. Jones

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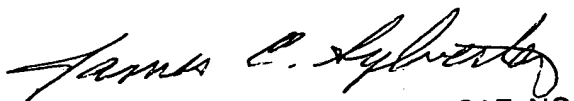
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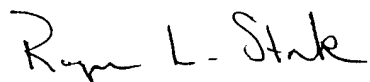
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TESTING AND EVALUATION OF THE CEOTRONICS, INC., MODEL TC 917 WIRELESS HEADSET

BACKGROUND

The Human Systems Center/YAM, Special Programs Office requested Air Force Medical Equipment Development Laboratory (AFMEDL) participation in evaluating and approving the Ceotronics, Inc., Wireless Headset; model TC 917 for use on board USAF aeromedical evacuation aircraft. Specific components of the wireless headset, model TC 917 that underwent the evaluation process included the model TC 917 basic unit (P/N: TC 917) and single unit 115 VAC/60 Hz battery charger (P/N: 40 06 530). All components of the model TC 917 were tested for airworthiness. Throughout this report, the term Equipment Under Test (EUT) refers to the model TC 917.

DESCRIPTION

The EUT is a portable, battery operated, wireless headset. It allows hands-free voice communication with voice activation or push-to-talk capability. The EUT came equipped with 10 channels ranging in frequency from 451.5 MHz to 453.75 MHz. Each step up or down the frequency range denotes a change in frequency of 0.25 MHz. To change a channel, remove the right ear cup and place a small slotted screwdriver into the channel select arrow, rotate the arrow to the desired channel. Performs automatic self-tests and displays the results of these tests on a status indicator. The unit operates on an internal, rechargeable Ni-Cad battery and can be recharged using the single unit 115 VAC/60 Hz battery charger (P/N: 40 06 530), (Figure 1). The EUT weighs approximately 1.38 lbs. The single unit 115 VAC/60 Hz battery charger (P/N: 40 06 530) weighs 2.96 lbs. The charger is 4.28 in. W. X 3 in. H. X 6 in. D.

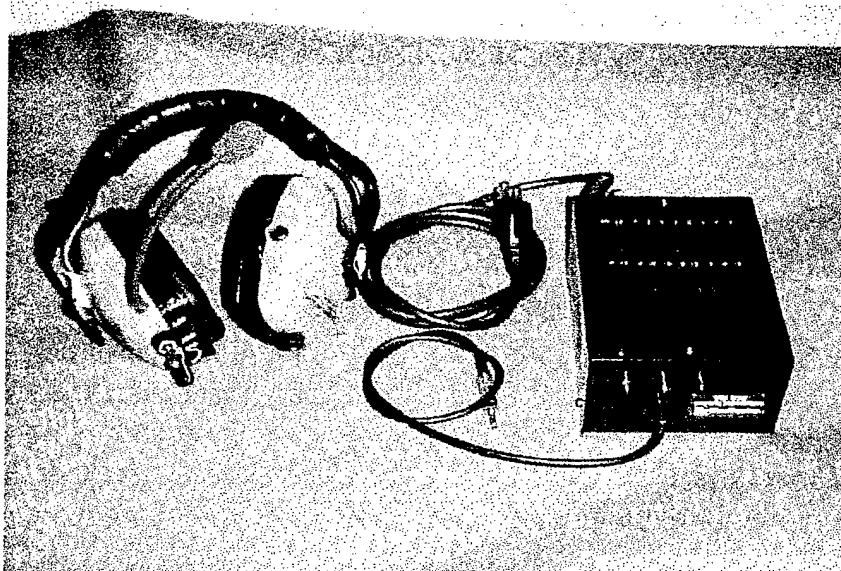


Figure 1. Ceotronics, Inc., Model TC 917 Wireless Headset

PROCEDURES

Test methods and performance criteria were derived from nationally recognized performance guidelines (1 & 2), military standards (3-8), and manufacturer's literature (9). The Aeromedical Research Procedures Guide describes additional safety and human interface issues to be considered during equipment testing (10). A test setup and performance check was developed specific to this EUT to verify its proper functioning under various testing conditions. All tests were conducted by AFMEDL personnel assigned to the Systems Research Branch, Biodynamics and Protection Division, Human Effectiveness Directorate, Air Force Research Laboratory, Brooks AFB, Texas unless otherwise noted.

The EUT was subjected to various laboratory and inflight tests to observe and evaluate its performance under anticipated operational conditions.

1. Initial Inspection
2. Vibration
3. Electromagnetic Interference (EMI)
4. Thermal/ Humidity Environmental Conditions, encompassing:
 - a. Hot Operation
 - b. Cold Operation
 - c. Humidity Operation
 - d. Hot Temperature Storage
 - e. Cold Temperature Storage
5. Hypobaric Conditions
 - a. Cabin Pressure/Altitude
 - b. Rapid Decompression to Ambient Pressure
6. Airborne Performance

INITIAL INSPECTION AND TEST PREPARATION

- a. The EUT was inspected for quality of workmanship, production techniques and pre-existing damage.
- b. The EUT was checked to ensure it met safety requirements and operating characteristics established in National Fire Protection Agency (NFPA) 99 (1); AFI 41-203, Electrical Shock Hazards (3); AFI 41-201, Equipment Management in Hospitals (4). Ground resistance and leakage current measurements to the charger unit were made at 115 VAC/60 Hz.
- c. The EUT was examined to ensure it met basic requirements for human factor design as outlined in MIL-STD 1472 (5).
- d. A test setup and performance check was developed to evaluate the EUT's operation in accordance with manufacturer/customer specifications throughout the various testing conditions.

TEST SETUP

The EUT was prepared for tests as follows:

1. Place the EUT on the person's head performing the test
2. Select push-to-talk or VOX (voice activated) mode on EUT
3. Place the individual wearing the EUT in test chamber or test aircraft and another individual outside the test chamber or aircraft
4. For vibration testing used an aluminum mannequin head
5. Place EUT's at various distances both inside and outside the aircraft to assess transmission and receiving strength.

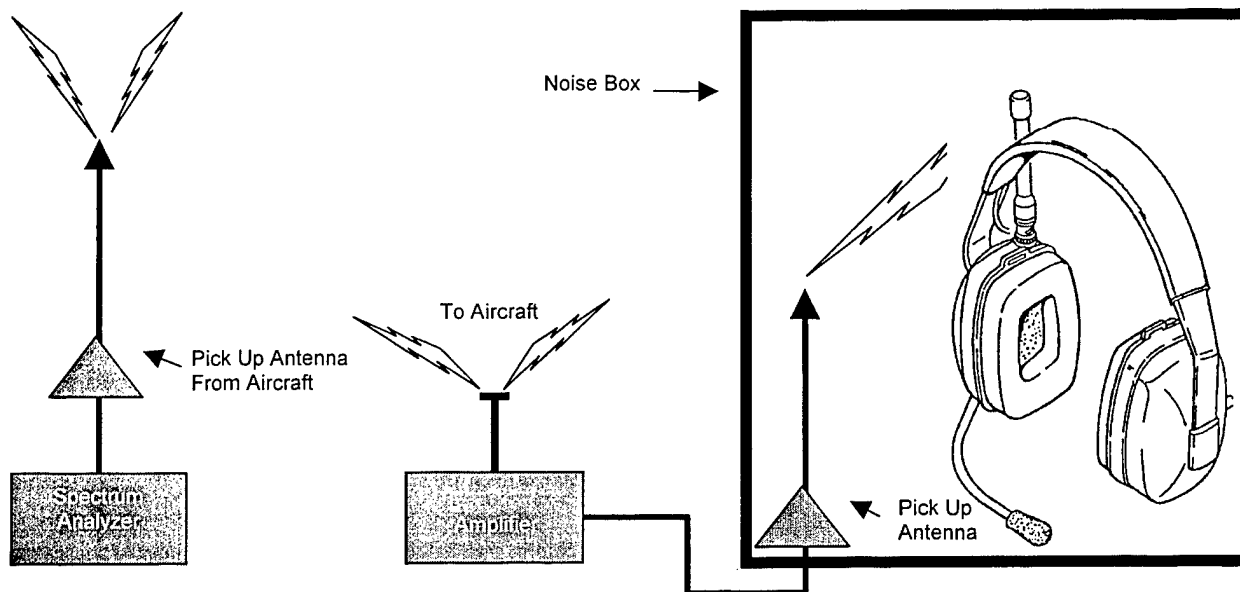


Figure 2. EMI Test Set-up

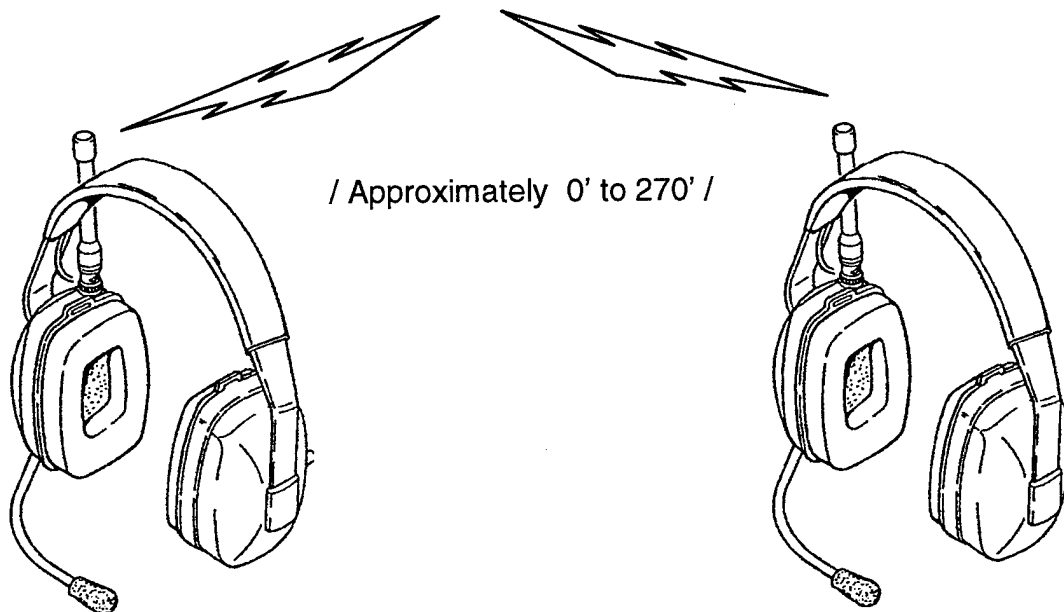


Figure 3. Laboratory Test Set-up

PERFORMANCE CHECK

The following performance check was used to validate the function of the EUT during each of the following test conditions: Placed the EUT squarely on AFMEDL personnel's head. Turn EUT on. At various distances (0-270 ft), assessed voice clarity in both the push-to-talk and voice activation mode.

Battery Operation as outlined in Ceotronics, Inc., Operating Instructions (9)

VIBRATION

Vibration testing is critical to determine "the resistance of equipment to vibrational stresses expected in its shipment and application environments" (6). Testing was conducted on a Unholtz-Dickey Corporation Vibration Test System, amplifier model SA30 and shaker model R16W. This testing involved a set of operational tests performed along each of three axes - X, Y, and Z. The EUT was mounted on an aluminum mannequin head, bolted to the vibration table simulating how it would be used in the aircraft. The EUT was subjected to vibration curves with similar intensities and durations as those derived from MIL-STD-810E, Category 10, Figures 514.4-16 and 514.4-17 (Figure 4).

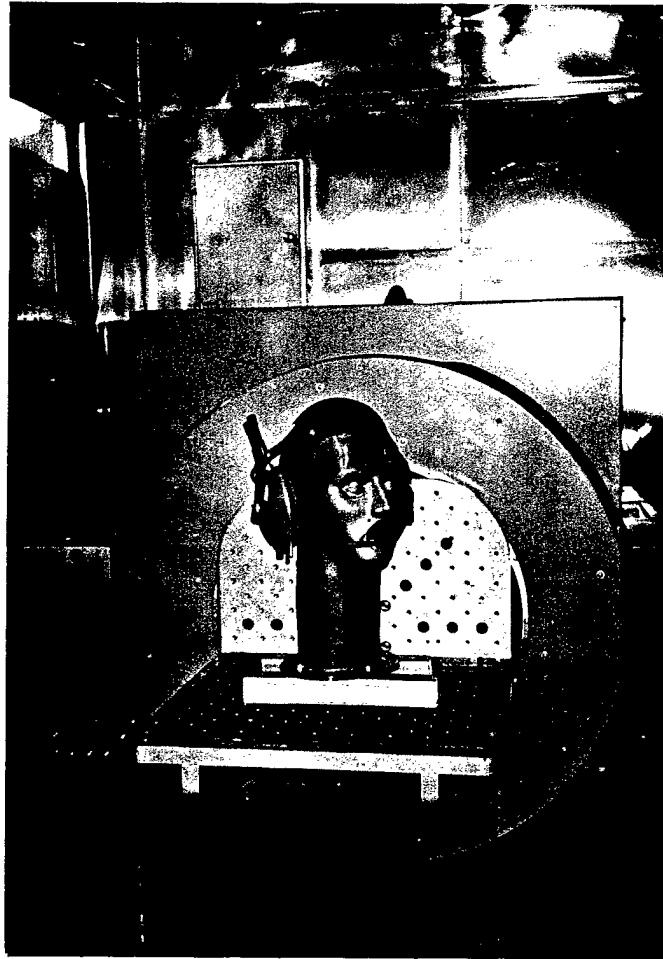


Figure 4. Vibration Table Mounting

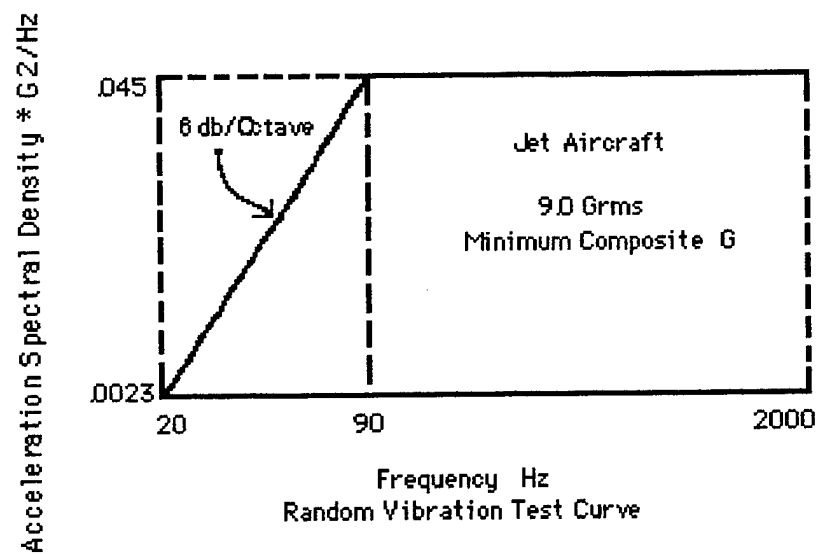


Figure 5. A. MIL-STD-810E, Category 10, figures 514.4-16 and 514.4-17

Sine-on-Random Curves

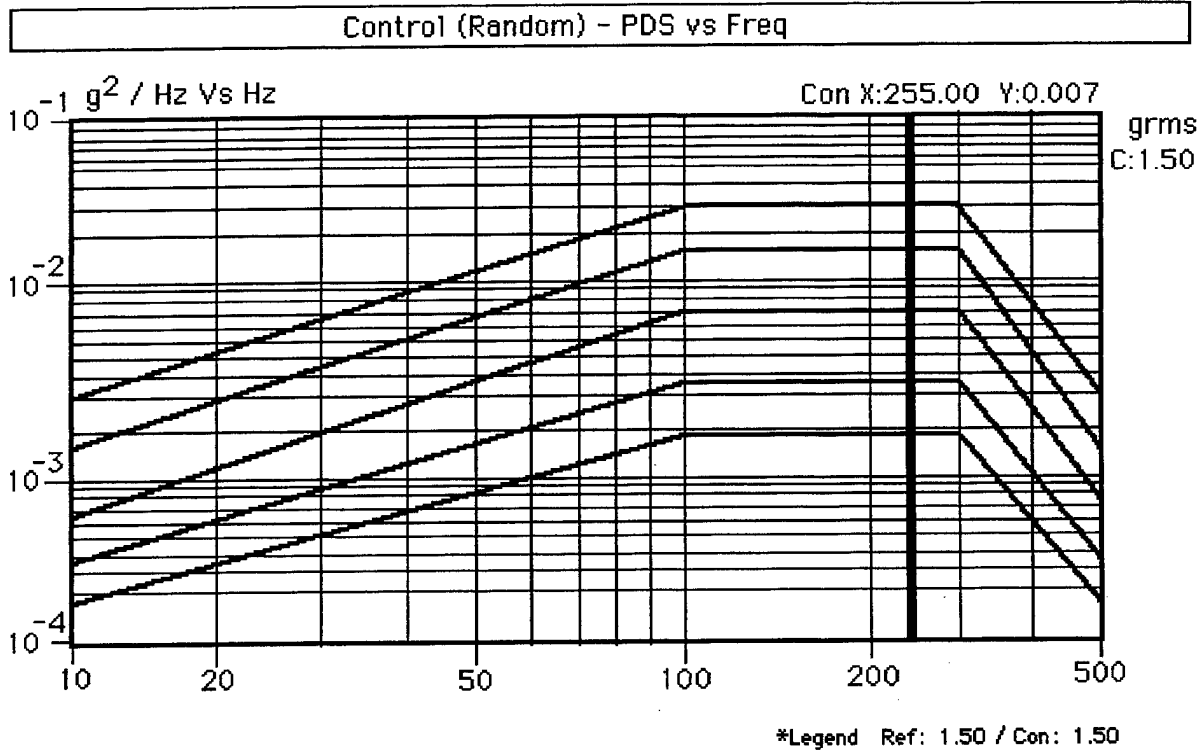
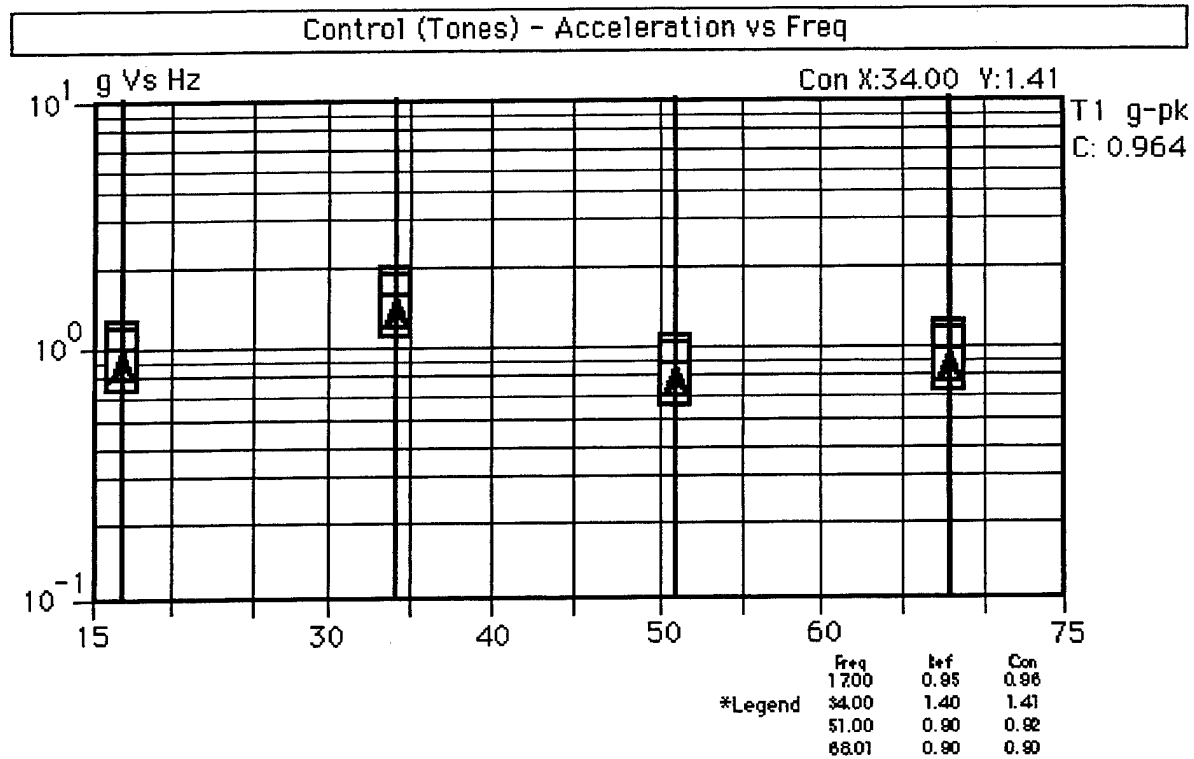


Figure 5. B&C. MIL-STD-810E, Category 10, figures 514.4-16 and 514.4-17

ELECTROMAGNETIC COMPATIBILITY

Electromagnetic compatibility is a primary concern for equipment to be used safely on USAF aeromedical evacuation aircraft. Emissions from medical equipment may cause electromagnetic interference (EMI) with potential influence on aircraft navigation and communications equipment. Medical devices may be susceptible to fields generated by aircraft equipment and malfunction in their presence.

The EUT was evaluated for compliance with MIL-STD-461D & MIL-STD-462D (7 & 8). ASC/ENAI engineers at Wright-Patterson AFB evaluated the electromagnetic compatibility data and determined the airworthiness of the medical device. Specific tests conducted were as follows:

a. Radiated Emissions (RE-102), "Radiated Emissions, Electric Field, 10 kHz to 18 GHz.": For Air Force aircraft applications, radiated emissions were tested in a narrower range of frequencies from 2 MHz - 1 GHz. This test measured the amount of EMI emitted by the EUT during operation. It verifies the EUT's potential to affect other equipment susceptible to electromagnetic emissions (i.e., aircraft navigation and communications equipment).

b. Conducted Emissions (CE-102), "Conducted Emissions, Power Leads, 10 kHz to 10 MHz.": For Air Force aircraft applications, conducted emissions were measured throughout the entire band of 10 kHz - 10 MHz. This test measured emissions generated by the EUT along its power supply lines. It was performed to assess the EUT's potential to affect other items connected to the same power source, particularly aircraft systems.

c. Conducted Emissions (CE-106), "Conducted Emissions, Antenna Terminal, 10 kHz to 40 GHz.": For Air Force aircraft applications, conducted emissions were measured throughout the entire band of 10 kHz - 40 GHz. This test measures spurious and harmonic outputs appearing at the antenna port of transmitters. It is also used to measure emissions at the antenna port of receivers, amplifiers, and transmitters in the stand-by mode. The basic concern of this test is to protect antenna-connected receivers both on and off the aircraft from being degraded due to radiated interference from the antenna associated with the EUT.

d. Radiated Susceptibility (RS-103), "Radiated Susceptibility, Electric Field, 10 kHz to 40 GHz.": For Air Force aircraft applications, radiated susceptibility was tested in a narrower frequency range from 30 MHz - 12.4 GHz at the following field strength levels: 20 V/M below 1 GHz and 60 V/M above 1 GHz (MIL-STD-461D field strength values from Table IV, Category Aircraft Internal). This test evaluated the EUT's resistance to predefined levels of EMI generated by antennas both internal and external to the aircraft.

e. Conducted Susceptibility (CS-101), "Conducted Susceptibility, Power Leads, 120 Hz to 50 kHz.": For Air Force aircraft applications, conducted susceptibility was tested throughout the entire frequency band from 30 Hz to 50 kHz. This test evaluated the EUT's ability to "withstand ripple voltages associated with allowable distortion of power source voltage wave forms."

f. Conducted Susceptibility (CS-114), "Conducted Susceptibility, Bulk Cable Injection, 10 kHz to 400 MHz.": For Air Force aircraft applications, conducted susceptibility was tested throughout the frequency band from 10 kHz to 200 MHz. This test determined whether "simulated currents that will be developed on platform cabling from electromagnetic fields generated by antenna transmission would affect the equipment under test."

g. Conducted Susceptibility (CS-115), "Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation". This test was performed to ensure the EUT could withstand the "fast rise and fall time that may be present due to platform switching operations and external transient environments such as lightning and electromagnetic pulse."

h. Conducted Susceptibility (CS-116), "Conducted Susceptibility, Damped Sinusoidal Transients, Cables and Power Leads, 10 kHz - 100 MHz," respectively. The "basic concept of this test is to simulate electrical current and voltage waveforms occurring in platforms from excitation of natural resonance's."

During phase 1 of emissions testing, all the EUT's electrical components were operating for the duration of the test to create the worst case scenario. In phase 2, the EUT was placed in a noise box with a pick-up antenna routed to an amplifier to boost the transmit signal throughout the aircraft. Another pick-up antenna routed through a spectrum analyzer assessed how the EUT would interfere with aircraft systems.

THERMAL/HUMIDITY ENVIRONMENTAL CONDITIONS

Extreme temperature and humidity testing determines if aeromedical equipment can be stored and operated during severe environmental conditions without experiencing physical damage or deterioration in performance (6). Extreme environmental conditions can have incapacitating effects on medical equipment including the following: changes in material characteristics, material dimensions, overheating, corrosion, changes in electronic components, and electronic or mechanical failures due to rapid water or frost formation.

Testing was conducted in a calibrated Thermotron Industry, model SM-32 environmental chamber. The EUT was placed in the center of the environmental chamber. All input and output cables and wires were routed through a port in the chamber wall, which were subsequently sealed with pre-cut sponge plugs. The other components of the test setup remained outside the chamber. For operational tests, the EUT was monitored continuously, and a performance check was conducted every 15 minutes. For storage tests, the EUT was placed in the chamber and remained non-operational throughout the storage portion of the test. The following describes the conditions of the environmental tests performed:

- a. Humidity: $94 \pm 4\%$ RH, $85^{\circ}\text{F} \pm 3.6^{\circ}\text{F}$ ($29.5^{\circ}\text{C} \pm 2^{\circ}\text{C}$) for 4 hr
- b. Hot Temp Operation: $120^{\circ}\text{F} \pm 3.6^{\circ}\text{F}$ ($49^{\circ}\text{C} \pm 2^{\circ}\text{C}$) for 2 hr
- c. Cold Temp Operation: $32^{\circ}\text{F} \pm 7.2^{\circ}\text{F}$ ($0^{\circ}\text{C} \pm 4^{\circ}\text{C}$) for 2 hr
- d. Hot Temp Storage: $140^{\circ}\text{F} \pm 3.6^{\circ}\text{F}$ ($60^{\circ}\text{C} \pm 2^{\circ}\text{C}$) for 6 hr

- e. Cold Temp Storage: $-40^{\circ}\text{F} \pm 3.6^{\circ}\text{F}$ ($-40^{\circ}\text{C} \pm 2^{\circ}\text{C}$) for 6 hr

HYPOBARIC CONDITIONS

Cabin Pressure/Altitude: Altitude testing is critical for aeromedical evacuation equipment due to potential effects of barometric pressure changes on operation of the equipment. A majority of the aircraft characterized as opportune aircraft available for use in aeromedical evacuation pressurizes their cabin atmosphere to barometric pressures equivalent to 8,000 - 10,000 ft above sea level. Altitude testing consisted of operating the EUT while ascending from ground level to 10,000 ft; stopping at 2,000 ft increments for performance checks; and then descending back to ground again stopping at 2,000 ft increments for performance checks. The rates of ascent and descent were 5,000 ft/min.

Rapid Decompression Testing: A rapid decompression (RD) is the loss of aircraft cabin pressurization and subsequent pressure equalization with ambient atmospheric pressures. It is important to assess medical equipment functioning during and after RD so as not to endanger patients, personnel, or the aircraft. The EUT operated inside the rapid decompression test chamber as the chamber was depressurized to an equivalent of 8,000 ft altitude. Then the chamber altitude was brought to 45,000 ft over a period of 60 seconds, held at 45,000 ft for a few minutes, and then returned to ground at a rate of 10,000 - 12,000 ft/min. The test was repeated twice more for a 7-second RD and for a 1-second RD. The EUT was monitored throughout the series of decompressions. Performance checks were assessed each time the unit returned to ground level.

AIRBORNE PERFORMANCE

Airborne performance evaluations are a cost-effective and invaluable means of validating clinical and operational suitability under actual operating conditions. In-flight test and analysis demonstrates the EUT's ability to provide quality communication on board USAF aircraft. Safe and reliable operation is the primary goal of the inflight evaluation and forms the basis for subsequent recommendations to the users.

Flight qualified aeromedical crewmembers from AFMEDL on a C-141 aeromedical evacuation mission conducted this phase of testing. The EUT was placed on an aeromedical crewmember's head and then evaluated for voice clarity at various distances in the aircraft. Human factor characteristics, form and fit to a human head, comfort factor during extended wear, setup/tear down times and securing locations of EUT and battery charger when not in use were also evaluated. Feedback from other aeromedical evacuation crewmembers participating in delivery of patient care was obtained concerning EUT human factor considerations.

EVALUATION RESULTS

INITIAL INSPECTION

Initial inspection revealed no manufacturing defects. The unit performed to the manufacturer's specification. Battery Operation revealed operation time well within manufacturer's specifications.

VIBRATION

During evaluation, the EUT was turned on and left on during the entire test. Pre and posttest performance checks revealed no degradation in voice clarity in either operating mode. The unit performed according to manufacturer's specifications and AFMEDL guidelines without any system discrepancies or malfunction.

ELECTROMAGNETIC COMPATIBILITY

ASC/ENAI, Wright-Patterson AFB failed the EUT upon completion of phase 1 due to multiple failures in susceptibility testing. Outlines of failures are as follows:

1. 10 V/M between 30-200 MHz with power charger connected using Push-to-Talk (PTT) mode, noise made voice transmission unintelligible. Required 20 V/M to pass.
2. 5 V/M between 200 MHz-1 GHz. Required 20 V/M to pass.
3. 5 V/M between 1-4 GHz. Required 60 V/M to pass.
4. Entire CE 106 and CS 115 evaluations.
5. Conducted Emissions test at the following frequencies and amounts, with the charger connected to the headset and PTT mode set.
 - a) 1.8-2.3 MHz/6db max.
 - b) 19.7-20.3 MHz/10db max.
 - c) 25-25.6 MHz/6db max.
 - d) 27.8-31 MHz/11db max.
 - e) 36-130 MHz/15db max.
 - f) 452.5 MHz/89db max.
 - g) 1.1 GHz/6db max.
 - h) 1.2 GHz/30db max.
 - i) 1.4 GHz/59db max.
 - j) 1.6 GHz/22db max.
 - k) 1.8 GHz/33db max.

During phase 2, ASC/ENAI, Wright-Patterson AFB certified the EUT for use in the aeromedical evacuation system on C-130H aircraft that has been retrofitted with a "glass cockpit" and on C-141 B aircraft that has not been retrofitted with a "glass cockpit." while operating from the internal Ni-Cad battery only. **Battery charger not certified for flight!**

THERMAL/HUMIDITY ENVIRONMENTAL CONDITIONS

The EUT operated satisfactorily in all modes during all five phases of testing.

HYPOBARIC CONDITIONS

1. Cabin Pressure/Altitude: The EUT performed in accordance with manufacturer's specifications throughout testing. The unit maintained voice clarity in all operating modes.
2. Rapid Decompression: The EUT operated satisfactorily following each rapid decompression event.

AIRBORNE PERFORMANCE

The inflight evaluation of the EUT was performed on a C-141 aeromedical evacuation mission. Evaluation confirmed that the unit would operate successfully during all phases of flight. Analysis of performance data indicated this unit was easy to enplane and deplane. The EUT were worn by AFMEDL research personnel and aeromedical evacuation crewmembers. During this evaluation it was determined that the units were comfortable to wear for short periods of time 2-3 hours and provided good hearing protection without using additional hearing protection. Units transmitted and received well at various distances throughout the aircraft (flight deck to palate position 13). Some considerations include: limitations on voice quality when using additional hearing protection, microphone placement must be within one finger width from lips for maximum voice clarity, and when using Voice Activation mode there is a time delay from when one person speaks to when the other person is clear to speak posing a training issue for crewmembers trying to teach patients how to use the EUT's in flight. EUT is not equipped with an external channel selection switch. Personnel must remove the headset in order to change channels/frequencies.

During this evaluation the EUT's were able to pick up transmissions from transmitters using similar frequencies outside the aircraft environment. Special concern regarding operational security (OPSEC) and communication security (COMSEC) may be required, even though, no direct communication could be established with those outside transmitters/receivers.

SUMMARY

AFMEDL found the Ceotronics, Inc., Model TC 917, wireless headset to be conditionally acceptable for use on all U.S. Air Force aeromedical evacuation aircraft while operating on the internal rechargeable Ni-Cad battery. Its operation was within expected parameters when subjected to electromagnetic interference (EMI), environmental extremes, simulated cabin

altitudes, and did not produce a hazard to patient or crew during rapid decompression. The following recommendations apply:

- a. EUT can only be used onboard C-130H aircraft that has been retrofitted with a "glass cockpit" and onboard C-141 B aircraft that has not been retrofitted with a "glass cockpit." while operating from the internal Ni-Cad battery only. **Battery charger not certified for flight!**
- b. Voice quality degrades when using additional hearing protection (Ear plugs).
- c. OPSEC/COMSEC concerns exist since no encryption voice technology is incorporated into the EUTs. Conversations conducted wearing the EUT should be restricted from discussing classified or sensitive information.
- d. Microphone placement must be within one finger width from lips for maximum voice clarity.
- e. When using Voice Activation mode there is a time delay from when one person speaks to when the other person is clear to speak posing a training issue for crewmembers trying to teach patients how to use the EUT's in flight.
- f. EUT is not equipped with an external channel selection switch. Personnel must remove the headset in order to change channels/frequencies.

REFERENCES

1. National Fire Protection Agency (NFPA) 99, Health Care Facilities Code
2. Emergency Care Research Institute (ECRI)
3. AFI 41-203, Electrical Shock Hazards
4. AFI 41-201, Equipment Management in Hospitals
5. MIL-STD 1472, Human Engineering Design Criteria for Military Systems, Equipment, and Facilities.
6. MIL-STD 810E, Environmental Test Methods and Engineering Guidelines.
7. MIL-STD 461D, Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference.
8. MIL-STD-462 D, Measurement of EMI Characteristics.
9. Ceotronics, Inc., (1996) Model TC917, Wireless Headset, Operating Instructions.
10. Aeromedical Research Procedures Guide, Internal Operating Instruction, Systems Research Branch, Air Force Research Laboratory.

APPENDIX
MANUFACTURER'S SPECIFICATIONS OF
CEOTRONICS, INC., MODEL TC 917
WIRELESS HEADSET

SPECIFICATIONS

General

Weight	Approximately 1.38 lbs. with battery
Freq. Range	430 to 470 MHz
Power	7.2 V Ni-Cad rechargeable battery/600 mAh.
Transmit Power	50 mW at the antenna/10 mW ERP
Transmit Range	Up to several hundred meters (yards)
Environmental	Temperature: -10°C to 55°C (operating)
Operation Mode	Voice Activated (VOX) and Push-to-Talk (PTT).
Channels	10